

Appendix A

INSTRUMENTED VEHICLE TRACK TESTS

Vehicle Measurements

An experiment was conducted which involved driving an instrumented vehicle (IV) repeatedly past the RSD-1000 remote sensor with the IV in a fixed mode of operation. The tests were performed on the NC Highway Patrol's 1.13 mile oval test track in Raleigh, NC. The IV's on-board instruments continuously measured CO, HC, NO, and CO₂ concentrations in the tailpipe exhaust during each pass of the remote sensor.

Table A1 lists the experiments performed. The IV passed the RSD-1000 repeatedly while emitting approximately 2% CO and then 8% CO. Limiting the air intake produced the 2% CO exhaust, while disconnecting the oxygen sensor produced the 8% CO exhaust. At each exhaust level the RSD was calibrated with a low CO/CO₂ ratio calibration gas (gas #1) and then a high CO/CO₂ ratio calibration gas (gas #4). The objective of the experiment was to determine whether the CO measurement biases that were observed in the gas experiments would be observed on the road with a motor vehicle.

Table A1. Instrumented Vehicle (IV) Runs Performed on Test Track

Calibration Gas	IV Operating Mode	Number of Passes
#1 [3.05% CO, 12.90% CO ₂ , 3940ppm HC, 3590ppm NO]	~ 2% CO	42
#4 [6.03% CO, 5.98% CO ₂ , 2795ppm HC, 1997.5ppm NO]	~ 2% CO	36
#1 [3.05% CO, 12.90% CO ₂ , 3940ppm HC, 3590ppm NO]	~ 8% CO	14
#4 [6.03% CO, 5.98% CO ₂ , 2795ppm HC, 1997.5ppm NO]	~ 8% CO	14

All passes were made at 45 mph under the vehicle's cruise control. To ensure that the IV passed under constant-applied throttle, the RSD-1000 was positioned near the crest of a long and gradual 0.3% uphill slope.

Results

A summary of the instrumented vehicle (IV) track tests is shown in Table A2, below. The Vehicle Control Modes in the first column are defined as follows:

A = Disable one O₂ sensor

B = Normal Operation

C = Disable O₂ sensor and block air intake

The sample size indicates the number of laps made on the track by the IV under the operating conditions shown. The mean and standard deviation (Std Dev) is shown for each test.

Table A2. RSD-1000 vs. Instrumented Vehicle in Track Tests

Vehicle Control Mode	Cal Gas	Sample Size	RSD Measured HC, ppm		Instrumented Car Measured HC, ppm		RSD Measured CO, %		Instrumented Car Measured CO, %	
			Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
A	1	42	106	89	98	3.2	1.78	0.24	2±0.5	
A	4	36	132	118	97	2.5	2.06	0.27	2±0.5	
B	4	6	150	149	18	1.3	0.05	0.06	0.026	0.016
C	1	13	199	93	186	3.1	7.74	0.25	9±0.5	
C	4	14	216	161	186	4.8	8.07	0.17	9±0.5	

The IV's on-board instruments substantiated that the IV passed the remote sensor with little variability in the CO and, as expected, higher variability in the HCs. There was little NO produced and detected during these passes; consequently, NO measurements were not analyzed. The IV's exhaust measurements were not compared directly with remote sensor data to evaluate sensor accuracy because the excess air in the IV's exhaust could not be quantified; therefore, the assumptions of the dry gas combustion equation could not be validated. Nevertheless, the results of the on-road experiment with the IV appear to corroborate the results of the puff tests with the RSD-1000. That is, the remote sensor's CO channel exhibited biases in the measurement of CO at levels higher and lower than the level contained in the calibration gas.